REMARKS

Claims 1, 2, 11 and 14 have been amended. Claim 10 has been canceled. Claims 1-9 and 11-30 are pending in this application.

Claims 1 and 2 stand rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claims 1 and 2 have been amended to correct any perceived indefiniteness. Applicants note that all pending claims are now in full compliance with 35 U.S.C. § 112.

Claims 1-6, 9, 11-13, 15, 16, 17-20, 23-27, 29 and 30 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Jiang et al. (U.S. Pub. No. 2002/0009880) ("Jiang") in view of Lopatin et al. (U.S. Patent No. 6,368,954) ("Lopatin") and Applicant's Admitted Prior Art. This rejection is respectfully traversed.

The claimed invention relates to a method of forming a copper damascene structure. As such, amended independent claim 1 recites a "method of forming a copper damascene structure" by *inter alia* "patterning a low-dielectric constant layer to form at least one opening through said low-dielectric constant layer" and "forming a tungsten nitride layer by atomic-layer deposition using sequential surface reactions." Amended independent claim 1 also recites "providing a copper layer in said at least one opening and in contact with said tungsten nitride layer, wherein said copper layer is selectively deposited by chemical vapor deposition."

Independent claim 17 recites a "method of forming a copper damascene structure" by inter alia "forming a material layer of methylsilsequiazane over a substrate; forming at least one opening through said methylsilsequiazane layer" and "forming a tungsten nitride layer by atomic-layer deposition using sequential surface reactions, said tungsten nitride layer being in contact with said at least one opening." Independent claim 17 also recites "providing a copper layer in said at least one opening."

Jiang relates to a "copper interconnect having a barrier layer (106, 206)." (Abstract). According to Jiang, the barrier layer is "a silicon containing metal barrier layer." (Paragraph [0006] at lines 1-2). Jiang emphasizes that the "silicon containing diffusion barrier layer 206 has a low resistance and excellent wettability to Cu and to dielectrics such as FSG." (Paragraph [0027] at lines 5-7). Jiang teaches that "[C]opper is then deposited over the silicon containing barrier layer." (Paragraph [0006] at lines 6-7).

Lopatin relates to a copper interconnect using atomic layer deposition. (Title). Lopatin teaches that the interconnect structure has "a barrier layer formed over a patterned semiconductor substrate using atomic layer deposition; a pre-seed layer formed using atomic layer epitaxy; a thick seed layer; a bulk copper interconnect layer; and a top sealing layer." (Col. 3, lines 25-30). Lopating teaches the steps of "depositing a layer of barrier material over said surface using atomic layer deposition; depositing a pre-seed layer of conducting material using atomic layer epitaxy; depositing a seed layer of conducting material" and "depositing a bulk interconnect layer." (Col. 3, lines 30-37).

The subject matter of claims 1-6, 9, 11-13, 15, 16, 17-20, 23-27, 29 and 30 would not have been obvious over Jiang in view of Lopatin and Applicant's Admitted Prior Art. Indeed, the Office Action fails to establish a *prima facie* case of obviousness. Courts have generally recognized that a showing of a *prima facie* case of obviousness necessitates three requirements: (i) some suggestion or motivation, either in the references themselves or in the knowledge of a person of ordinary skill in the art, to modify the reference or combine the reference teachings; (ii) a reasonable expectation of success; and (iii) the prior art references must teach or suggest all claim limitations. See e.g., In re Dembiczak, 175 F.3d 994, 50 U.S.P.Q.2d 1614 (Fed. Cir. 1999); In re Rouffet, 149 F.3d 1350, 1355, 47 U.S.P.Q.2d 1453, 1456 (Fed. Cir. 1998); Pro-Mold & Tool Co. v. Great Lakes Plastics, Inc., 75 F.3d 1568, 1573, 37 U.S.P.Q.2d 1626, 1630 (Fed. Cir. 1996).

In the present case, none of Jiang, Lopatin and Applicant's Admitted Prior Art, whether considered alone or in combination, teach or suggest the limitations of amended independent claim 1 and of independent claim 17. None of the prior art references teaches

or suggests "forming *a tungsten nitride layer by atomic-layer deposition using sequential surface reactions*" and "providing a copper layer . . . i*n contact with* said tungsten nitride layer, wherein said copper layer is *selectively deposited by chemical vapor deposition*," as amended independent claim 1 recites (emphasis added). The prior art references also fail to teach or suggest "forming a material layer of methylsilsequiazane over a substrate" and "forming at least one opening through said methylsilsequiazane layer" and "forming *a tungsten nitride layer by atomic-layer deposition using sequential surface reactions*, said tungsten nitride layer being in contact with said at least one opening" and "providing a copper layer in said at least one opening," as independent claim 17 recites (emphasis added).

As noted above, Jiang relates to "a silicon containing metal barrier layer" (paragraph [0006] at lines 1-2), and not to "a tungsten nitride layer," much less to the formation of "a tungsten nitride layer by atomic-layer deposition using sequential surface reactions," as amended independent claim 1 and independent claim 17 recite. Similarly, Lopatin fails to teach or suggest teaches "forming a tungsten nitride layer by atomic-layer deposition using sequential surface reactions," as amended independent claim 1 and independent claim 17 recite. Lopatin also fail to teach or suggest "providing a copper layer . . . i*n contact with* said tungsten nitride layer, wherein said copper layer is selectively deposited by chemical vapor deposition," as amended independent claim 1 recites (emphasis added). In Lopatin, the pre-seed layer of conducting material is formed over the barrier layer using atomic layer epitaxy, and not selective deposition by chemical vapor deposition, as in the claimed invention. (Col. 3, lines 30-37). Further, Applicant's Admitted Prior Art fails to teach or suggest the limitations of amended independent claim 1 and independent claim 17. For at least these reasons, the Office Action fails to establish a prima facie case of obviousness and withdrawal of the rejection of claims 1-6, 9, 11-13, 15, 16, 17-20, 23-27, 29 and 30 is respectfully requested.

Claims 7, 8, 21 and 22 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Jiang in view of Lopatin, Applicant's Admitted Prior Art and Farrar

(U.S. Pub. No. 2002/0048931) ("Farrar"). This rejection is respectfully traversed.

Claims 7 and 8 depend on amended independent claim 1 and recite that the low-dielectric constant layer "is formed by spin coating to a thickness of about 2,000 to 50,000 Angstroms" (claim 7) and "to a thickness of about 5,000 to 20,000 Angstroms" (claim 8). Claims 21 and 22 depend on independent claim 17 and recite that the methylsilsequiazane layer "is formed by spin coating to a thickness of about 2,000 to 50,000 Angstroms" (claim 21) and "to a thickness of about 5,000 to 20,000 Angstroms" (claim 22).

Farrar relates to a "damascene structure with a plurality of low dielectric constant insulating layers acting as etch stops." (Abstract). According to Farrar, the low dielectric constant materials "have similar methods of formation and similar capacities to withstand physical and thermal stress" and "act as insulating layers through which trenches and vias are formed." (Abstract). Farrar also teaches barrier layer 72 formed of "metals, such as titanium (Ti), zirconium (Zr), tungsten (W), or hafnium (Hf), or metal compounds, such as tantalum nitride (TaN) or silicon nitride (Si_3N_4)." (Paragraph [0046] at lines 1-4).

The subject matter of claims 7, 8, 21 and 22 would not have been obvious over Jiang in view of Lopatin, Applicant's Admitted Prior Art and Farrar. The Office Action fails again to establish a *prima facie* case of obviousness. Jiang, Lopatin, Applicant's Admitted Prior Art and Farrar, whether considered alone or in combination, fail to teach or suggest all limitations of amended independent claim 1, of independent claim 17, and of dependent claims 7, 8, 21 and 22. None of the cited prior art references teaches or suggests "forming *a tungsten nitride layer by atomic-layer deposition using sequential surface reactions*" and "providing a copper layer . . . i*n contact with* said tungsten nitride layer, wherein said copper layer is selectively deposited by chemical vapor deposition," as amended independent claim 1 recites (emphasis added). The prior art references also fail to teach or suggest "forming a material layer of methylsilsequiazane over a substrate" and "forming at least one opening through said methylsilsequiazane layer" and "forming *a tungsten nitride layer by atomic-layer deposition using sequential surface reactions*, said

tungsten nitride layer being in contact with said at least one opening" and "providing a copper layer in said at least one opening," as independent claim 17 recites (emphasis added). For at least these reasons, the Office Action fails to establish a prima facie case of obviousness and withdrawal of the rejection of claims 7, 8, 21 and 22 is respectfully requested.

A marked-up version of the changes made to the specification and claims by the current amendment is attached. The attached page is captioned "**Version with markings to show changes made.**"

In view of the above, each of the presently pending claims in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to withdraw the outstanding rejection of the claims and to pass this application to issue.

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Respectfully submitted,

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Version With Markings to Show Changes Made

1. (Amended) A method of forming a copper damascene structure, said method comprising the steps of:

[directly] patterning a low-dielectric constant layer to form at least one opening through said low-dielectric constant layer;

forming a tungsten nitride layer by atomic-layer deposition using sequential surface reactions, said tungsten nitride layer being in contact with said at least one opening; and

providing a copper layer in said at least one opening and in contact with said tungsten nitride layer, wherein said copper layer is selectively deposited by chemical vapor deposition.

2. (Amended) The method of claim 1, wherein said low-dielectric constant layer includes a material selected from the group consisting of methylsilsequiazane, polyimide, spin-on-polymers, flare, polyarylethers, parylene, polytetrafluoroethylene, benzocyclobutene, [SILK,] fluorinated silicon oxide, and hydrogen silsesquioxane [and NANOGLASS].

11. (Amended) The method of claim [10] 1, wherein said copper layer is selectively deposited at a temperature of about 300°C to about 400°C.

14. (Amended) [The method of claim 1] A method of forming a copper damascene structure, said method comprising the steps of:

patterning a low-dielectric constant layer to form at least one opening through said low-dielectric constant layer;

forming a tungsten nitride layer by atomic-layer deposition using sequential surface reactions, said tungsten nitride layer being in contact with said at least one opening; and

providing a copper layer in said at least one opening, wherein said copper layer is formed by electroless deposition.